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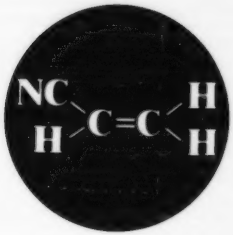
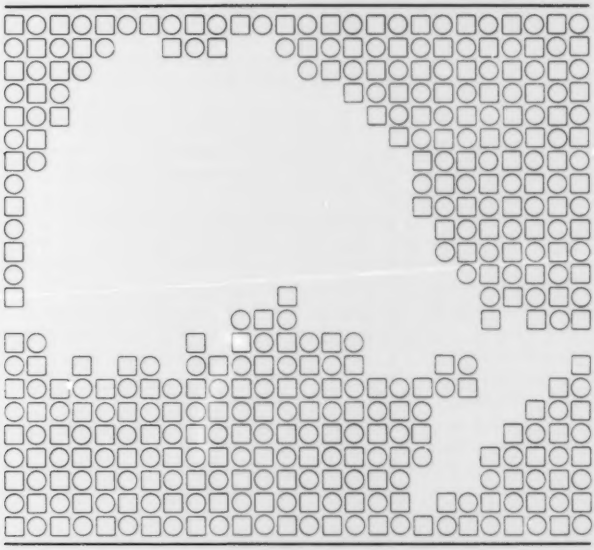
Ministry of
Labour

Occupational
Health and Safety
Division

Designated Substances in the Workplace: A Guide to the Acrylonitrile Regulation





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Designated Substances in the Workplace: A Guide to the Acrylonitrile Regulation

September 1987

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Table of Contents

		Page
Introduction		1
1.	**The Hazards of Acrylonitrile in the Workplace**	3
	What Is Acrylonitrile and How Is It Used?	3
	Why Is Acrylonitrile a Health Hazard?	3
	How Can Workers Be Exposed to Acrylonitrile?	4
	Fire, Chemical Reaction and Explosion Hazards of Acrylonitrile	5
2.	**The Acrylonitrile Regulation**	7
	Who Is Covered by the Acrylonitrile Regulation?	7
	Does the Regulation Apply to Construction Projects?	7
	Are Users of Products Made from Acrylonitrile Covered?	7
	Must the Employer Protect Workers Who Are Present in the Workplace but Who Are Not Working Directly for the Employer?	8
	What Are the Allowable Airborne Concentrations of Acrylonitrile?	9
3.	**Assessing and Controlling Exposure to Acrylonitrile**	10
	The Assessment	10
	The Control Program	12
	Control Program for Fabricating Operations Using Acrylonitrile-Based Polymers	12
	Control Program for Operations Using Acrylonitrile	14
	Engineering Controls	14
	Hygiene Practices and Housekeeping	16
	Maintenance and Cleaning of Equipment	16
	Storage and Dispensing of Acrylonitrile	17
	Clean-Up of Spills	18
	Disposal	19
	First Aid and Safety Precautions	19
	Protective Clothing	19
	Respiratory Protection	20
	The Type of Respirator Required	20
	Air Monitoring for Acrylonitrile	21
	Training	22

4. Medical Surveillance for Exposure to Acrylonitrile 23

Clinical Tests 24
Action Levels 24
The Examining Physician 25
Physician Reporting Protocol 25

5. Appendices 27

Appendix 1: First Aid for Over-Exposure to Acrylonitrile 29
Appendix 2: Process Flow Sheets 30
Appendix 3: Acrylonitrile Data Sheet 34
Appendix 4: Regulations made under the Occupational Health and Safety Act 36
Appendix 5: Ministry of Labour District Offices 38

Introduction

This guide has been prepared to help employers, workers, members of joint health and safety committees, supervisors and occupational health personnel meet the requirements of the designated substance regulation respecting acrylonitrile in the workplace and understand the responsibilities this regulation places on all participants in the workplace health and safety system.

The advice in this guide is the interpretation, by officials of the Occupational Health and Safety Division, of the Occupational Health and Safety Act (the Act) and regulations.

The advice does not have binding effect but is intended to provide general answers to possible questions asked in the context of a specific situation. It is being used by staff of the ministry to assist in the administration of the acrylonitrile regulation.

Questions of construction and application will find their ultimate answer given by the courts where a contest ensues as to construction or application of a legislative provision.

The Occupational Health and Safety Division of the Ministry of Labour is responsible for administering the Act. The Regulation respecting Acrylonitrile, Ontario Regulation 733/84, was filed with the Registrar of Regulations on November 16, 1984. The provisions relating to the assessment came into force on the date of filing; those relating to control measures came into force on February 14, 1985.

This guide is intended as a supplement to the booklet entitled **Designated Substances in the Workplace: A General Guide to the Regulations** to help employers, workers, and members of the joint health and safety committees meet the requirements of the acrylonitrile regulation. This guide reviews the uses and health effects of acrylonitrile and provides information on the application of the regulation, allowable exposure levels, the assessment and control program and medical surveillance.

It is important that both this guide and the general guide to the regulations, referred to above, be consulted.

For further information on any aspect of the acrylonitrile regulation, contact the Inspectorate of the Ministry of Labour at the appropriate district office. Appendix 5 lists the addresses and telephone numbers of the district offices of the ministry.

1. The Hazards of Acrylonitrile in the Workplace

What Is Acrylonitrile and How Is It Used?

Acrylonitrile is a clear liquid that may be colourless or yellow. It is explosive, flammable and toxic. Acrylonitrile readily reacts with other chemicals to produce long, chain-like molecules (polymers). Two major acrylonitrile-based polymers are acrylonitrile-butadiene-styrene (ABS) resins and styrene-acrylonitrile (SAN) resins. Acrylonitrile-based polymers are used to produce nitrile rubbers, plastics, acrylic fibres, coatings and adhesives. A wide variety of goods, including automotive parts, clothing, carpets, construction plastics, telephone and appliance casings, gaskets, seals, hoses and shoe soles, are manufactured from acrylonitrile-based materials.

Acrylonitrile is often referred to as AN. It may also be known as 2-propenenitrile, vinyl cyanide, VCN and cyanoethylene.

Why Is Acrylonitrile a Health Hazard?

Like many toxic substances, acrylonitrile can be harmful as a result of a high dose received in a short period of time (acute exposure) or following long-term exposure to lower doses (chronic exposure).

Acute acrylonitrile poisoning can be fatal. Symptoms of acute poisoning include irritation of the eyes and nose, limb weakness, laboured breathing, dizziness, headaches, convulsions, impaired judgement, nausea, vomiting and diarrhea. Skin contact with acrylonitrile can cause itching and rash, and blisters that appear several hours after contact. If splashed into the eyes, acrylonitrile can cause eye damage.

Damage to the liver, lung, nervous system and kidneys has been observed in animals exposed to high levels of acrylonitrile in laboratory experiments. Some humans accidently exposed to high levels of acrylonitrile have shown signs of anaemia (low red blood cell count) and jaundice (yellow skin colour usually due to liver impairment).

The major health concern with regard to **chronic acrylonitrile exposure** is that it may cause cancer. Laboratory studies indicate that acrylonitrile can cause cancer in animals. Epidemiological studies (studies of the incidence of illness or death in groups of people) have found increased rates of lung cancer in workers exposed to acrylonitrile. Some epidemiological studies suggest that exposure to acrylonitrile may also be associated with an increased incidence of other types of cancer, including cancers of the stomach, lymph system and brain. However, the epidemiological studies of humans are not regarded as conclusive.

As a result of the positive evidence that acrylonitrile can cause cancer in animals and the uncertain data on its effects on humans, it has been concluded that acrylonitrile should be treated as a potential human carcinogen (cancer-causing agent).

How Can Workers Be Exposed to Acrylonitrile?

Workers may be exposed to acrylonitrile through inhaling its vapours, through direct skin contact with the liquid or through ingestion.

1. Inhalation of Vapours:

"Vapour" refers to the gaseous form of a substance that has been given off (evaporated) from a liquid. The "volatility" of a liquid refers to how rapidly it evaporates at a given temperature. The higher the temperature of the liquid, the more rapidly it will release vapour.

Acrylonitrile is very volatile, and exposure to its vapours can easily occur wherever the liquid is present unless adequate controls are in place. Acrylonitrile vapour may also be released from acrylonitrile-based polymers, particularly when they are heated during processing.

2. Direct Contact With Liquid Acrylonitrile:

Acrylonitrile is easily absorbed into the body when the liquid comes in contact with the skin. Direct contact can also cause local skin irritation and blisters. Skin absorption and injury are especially likely if the liquid is absorbed into clothing or leather shoes and held in contact with the skin for an extended period of time.

Acrylonitrile can cause eye damage if splashed into the eyes.

3. Ingestion:

Ingestion of acrylonitrile can occur through food, drink, chewing gum or tobacco products that are brought into the workplace and become contaminated. Ingestion of acrylonitrile can also occur when eating or smoking with hands that are contaminated or following the handling of contaminated clothing.

Fire, Chemical Reaction and Explosion Hazards of Acrylonitrile

Acrylonitrile is a flammable liquid and its vapours can easily form explosive mixtures with air. Acrylonitrile may explode if it comes into contact with strong oxidizers or acids. It may release hazardous chemicals if combined with copper, ammonia or amines. Pure acrylonitrile can spontaneously polymerize (form polymers), with a resulting build-up of pressure and heat. Contact with bases, acids, high temperatures and radiation can also cause acrylonitrile to polymerize. If uncontrolled polymerization occurs, there is a danger that containers of acrylonitrile may explode and acrylonitrile may be released. To prevent spontaneous polymerization, acrylonitrile is usually stored with a polymerization inhibitor.

Where there is doubt about whether a chemical is an oxidizer, acid, base or other substance that can form a hazardous reaction with acrylonitrile, a handbook on reactive chemical hazards should be consulted.

If polymers made from acrylonitrile are burned, toxic gases, such as hydrogen cyanide, may be released.

2. The Acrylonitrile Regulation

Who Is Covered by the Acrylonitrile Regulation?

With the exception of construction projects and users of finished products made from acrylonitrile, the acrylonitrile regulation applies to all employers and workers at workplaces where acrylonitrile is present, produced, used, handled or stored and at which a worker is likely to inhale, absorb or come into contact with acrylonitrile.

Fabricators of goods made from acrylonitrile-based polymers **are** covered by the regulation. Fabricators include processors, converters, compounders, moulders and extruders of acrylonitrile-based polymers such as ABS resins, SAN resins and nitrile rubbers.

Does the Regulation Apply to Construction Projects?

The regulation does not apply to employers who primarily carry on the business of construction or to the workers of such employers.

Are Users of Products Made from Acrylonitrile Covered?

The regulation does not apply to employers and workers at workplaces where acrylonitrile is not produced, processed or used and where the only possible exposure to acrylonitrile could result from the presence, use, handling or storage of goods made in the last stage of a process using acrylonitrile-based polymers.

This exemption applies to workplaces where the only exposure to acrylonitrile could be from finished products made from

acrylonitrile-based polymers, such as pipe, refrigerator linings, telephones and finished acrylic fibres. Examples of processes that are not covered by the regulation include:

- bending, forming, machining and decorating, or other mechanical operations not involving heat or pressure, of finished products manufactured from resins or rubbers; for example, the cutting of an ABS pipe to fit into a plumbing system;
- assembling into a consumer product the finished products made from an acrylonitrile-based resin or rubber; for example, assembly of shoes using nitrile rubber soles or assembly of automobiles using parts made from nitrile rubbers or ABS resins;
- use of acrylic fibres to make carpets or clothes and use of acrylic emulsions to make industrial floor waxes and coatings, inks and paints;
- use of consumer products such as refrigerators, coffee cups or shoes made from acrylonitrile-based polymers.

Must the Employer Protect Workers Who Are Present in the Workplace but Who Are Not Working Directly for the Employer?

An employer to whom the regulation applies must take every reasonable precaution to protect a worker present in the workplace, even if that worker is not directly employed by the employer. (This may apply, for example, to employees of a contractor and equipment repair persons.) Such a worker must comply with the requirements of the employer. It would be reasonable for the employer to ensure that the exposure of these workers is within the exposure limits or that where conditions set out in section 5 exist, the appropriate respiratory protection is provided. These obligations are not applicable to employers who primarily carry on the business of construction nor to the workers of such employers.

What Are the Allowable Airborne Concentrations of Acrylonitrile?

The worker must not be exposed to acrylonitrile levels greater than those specified in the regulation.

Time-Weighted Average Exposure

The employer must take all necessary measures by means of engineering controls, work practices, and hygiene practices and facilities to ensure that the time-weighted average exposure of workers to airborne acrylonitrile is reduced to **the lowest practical level.**

In any case, the time-weighted average exposure of a worker to airborne acrylonitrile must not exceed **2 ppm** (two parts acrylonitrile per million parts of air by volume) or **4.3 milligrams per cubic metre (mg/m^3)** of air.

The time-weighted average exposure of a worker is calculated on the basis of cumulative weekly exposure (40 hours), as indicated in the Schedule appended to the regulation.

Maximum Exposure Concentration

The maximum exposure of a worker must not exceed **10 ppm** or **21.7 mg/m^3** of air at any time.

Employers and workers are required to comply with these exposure concentrations by means of engineering controls, work practices, and hygiene practices and facilities. The use of respirators to achieve these limits is restricted to certain conditions, as described on pages 8 to 9 of **A General Guide to the Regulations.**

3. Assessing and Controlling Exposure to Acrylonitrile

The Assessment

Chapter 2 of **A General Guide to the Regulations** describes a procedure for conducting an assessment that should be used to determine the extent of exposure of workers to acrylonitrile. When carrying out the assessment, you must note all the processes involving acrylonitrile or acrylonitrile-based polymers from which acrylonitrile may be released into the workplace. In addition, you must note all possible sources of contact with acrylonitrile that may result in ingestion or skin absorption.

If your plant uses acrylonitrile, the assessment should address the following points:

- How and where is acrylonitrile stored?
- Is the acrylonitrile used in batch or continuous processes? If batch processes, how often does exposure occur?
- What are the operating temperatures and pressures of the processes used?
- How often are reaction vessels opened for such processes as cleaning, maintenance and scraping? What precautions are taken to prevent exposure while they are open?
- Is there a potential for leaks of acrylonitrile around pumps, vents, gaskets, valves, flanges and connections?
- What leak detection procedures are in place and what maintenance practices are followed to prevent leaks from occurring? Are orderly records kept of the maintenance performed?

- What are the procedures for unloading acrylonitrile, transporting acrylonitrile within the workplace and charging process vessels with acrylonitrile?
- What personal protective equipment is available and used? If respirators are used, is there a program to ensure proper fitting, cleaning and maintenance of respirators?
- What procedures are in place for dealing with emergencies such as spills, leaks, fires, explosions and acute poisoning? Are these procedures in written form and are workers well-acquainted with them?
- What are the disposal procedures for material contaminated with acrylonitrile?

Fabricating acrylonitrile-based products involves processes such as injection moulding, extrusion and calendering to make goods such as pipes, telephone cases and hoses. If your plant is engaged in fabricating products from acrylonitrile-based polymers, the assessment should note:

- the concentration of residual acrylonitrile in the polymer. This information is usually available from the supplier;
- the potential for process malfunctions that may cause overheating of the resin or rubber and resultant release of acrylonitrile;
- the potential for emissions of acrylonitrile from processing equipment. Such emissions are best controlled through enclosure and local ventilation;
- the operating temperature and pressure of the fabricating process;
- the personal protective equipment that is available and used.

All assessments should also note the use and adequacy of local exhaust and general ventilation. In some cases, tests of the ventilation system should be performed.

It may be necessary to include air sampling as part of the assessment for acrylonitrile. Chapter 6 of **A General Guide to the Regulations** explains in detail the procedures for air monitoring that should be used to determine the concentration of acrylonitrile in workplace air. The acrylonitrile regulation references a measurement code that specifies methods and procedures to be used for the air sampling and analysis required to determine compliance with the exposure limits prescribed by the regulation and to meet the requirements of the acrylonitrile control program if one is required.

The Control Program

If the assessment concludes that the health of a worker may be affected by exposure to acrylonitrile, then a control program is required.

If an acrylonitrile control program is required, it must include provisions for engineering controls, work practices, hygiene practices and facilities, air monitoring, record keeping and medical surveillance. In addition, the acrylonitrile regulation requires a training program for supervisors and workers on the health effects of acrylonitrile and the provisions of the control program.

Because the potential for exposure to acrylonitrile is very different for fabricating operations using acrylonitrile-based resins or rubbers than it is for primary users of acrylonitrile, control programs for these two types of plants will emphasize different control measures, as described below.

Control Program for Fabricating Operations Using Acrylonitrile-Based Polymers

As explained in Chapter 2 of this guide, the acrylonitrile regulation applies to employers who fabricate products from acrylonitrile-based polymers, such as ABS and SAN resins and nitrile rubbers.

Release of acrylonitrile may occur when the polymer is subjected to heat or pressure during processing. Generally, the degree to which acrylonitrile vapour may be released is related to the amount of residual acrylonitrile in the raw material; employers can therefore control exposure to acrylonitrile by ensuring that they purchase resins or rubbers with the lowest possible residual acrylonitrile content.

Release of acrylonitrile vapour from fabricating processes is particularly likely during process malfunctions, particularly if overheating occurs. At high temperatures, the polymer may depolymerize, with the resulting release of acrylonitrile vapour. Therefore, good maintenance of equipment and written procedures for dealing with process malfunction are important components of the acrylonitrile control program. If process malfunction results in the formation of waste resin with a high acrylonitrile content, workers cleaning up the waste must wear appropriate protective equipment. Workers not involved in the clean-up should be evacuated from the area. Disposal of acrylonitrile-contaminated waste must be in accordance with the requirements of the Ministry of the Environment.

Control of acrylonitrile exposure in fabricating plants is mainly accomplished through enclosure and local exhaust ventilation, which should be provided at extrusion heads, mould openings and any other points where vapours may be emitted from the hot polymer. Process controls and work practices can also help to reduce exposure. For example, resins should be processed at the lowest temperature and in the shortest time possible. Purging the nozzle before the resin cools and solidifies in the barrel will help to limit the formation of degradation products. The polymer should be handled with gloves that are impervious to acrylonitrile.

The control program for fabricating operations must also include provisions for a training program, as described below on page 22. Where air monitoring and/or respirators are required, practices

should conform to the Codes referenced by the regulation, as described below on pages 20 to 22.

Control Program for Operations Using Acrylonitrile

Engineering Controls

Engineering controls for primary users of acrylonitrile can be grouped into categories outlined in Chapter 4 of **A General Guide to the Regulations**. Some of the engineering controls that have been found to be useful in controlling acrylonitrile exposure are described below.

Process Controls

Alarms or automatic shut-off switches can be installed on equipment to warn of high pressure, high temperature, pump failure and low or high levels, which may indicate problems in the process or ventilation system failure. Automated mixing, metering and dispensing operations will reduce worker exposure and the likelihood of spills. Process changes can be used to minimize the time workers must spend inside vessels or working with open vessels. For example, mechanical methods of stripping polymer from the sides of vessels will reduce worker exposure.

Several methods have been developed to reduce acrylonitrile exposure resulting from the necessity to flush sample lines in order to obtain a representative sample for quality control. One method is to use sampling loops with piston-type sample valves, which release a pre-set amount of liquid. Another approach is to locate the sampling point in a ventilated booth.

Enclosure/Isolation

All processes involving acrylonitrile must be enclosed, and every effort made to prevent leaks. Where reasonable and practicable,

areas where acrylonitrile exposure may occur should be isolated from other areas of the plant. Workers should preferably be stationed in control rooms kept under positive pressure.

The following measures have been suggested as effective ways of controlling emissions from storage and reactor systems containing acrylonitrile:

- use of welded connections on lines containing acrylonitrile;
- use of packed, mechanical or double mechanical seals on agitator shafts, pumps and compressors;
- use of enclosure and local ventilation around potential sources of emissions such as filters, dryers or pump glands;
- sealing tops of tanks and manway covers on vessels operating at atmospheric pressure;
- using rupture disc systems on vessels that contain acrylonitrile under pressure to eliminate leaks from pressure relief valves and prevent emissions due to excessive pressure; and
- permanently opening vent-line dampers to avoid tank pressurization, and the application of slight negative pressure on atmospheric pressure vessels.

A regular program of leak detection and maintenance is important to ensure that acrylonitrile emissions do not occur.

Ventilation

Local ventilation is necessary at all points where acrylonitrile may be emitted, such as around filters and dryers, sampling stations, manways and agitator seals. Flexible exhaust hoses can be used for intermittent maintenance operations or when leaks or spills occur.

In addition to local exhaust ventilation, good general ventilation is necessary to ensure that the concentration of airborne acrylonitrile

remains low. Chapter 4 of **A General Guide to the Regulations** describes general principles of good local and general ventilation.

Because acrylonitrile is a highly flammable substance, it is essential that there be no potential sources of ignition in the ventilation system. Contaminated air that is vented to the outside must meet the requirements set by the Ministry of the Environment.

Hygiene Practices and Housekeeping

Workers who may be exposed to acrylonitrile should be provided with shower facilities equipped with a "double locker" system so that street clothes will not become contaminated.

Eating, drinking, chewing gum and smoking must be forbidden in areas where acrylonitrile contamination may occur.

Good housekeeping is important in areas where acrylonitrile is used. All spills must be cleaned up immediately. Dry sweeping and compressed air must not be used to clean surfaces and floors that may be contaminated with acrylonitrile.

Maintenance and Cleaning of Equipment

Regular equipment maintenance and records of such maintenance are necessary to ensure that spills and leaks of acrylonitrile do not occur. Strict precautions are necessary to protect workers from acrylonitrile exposure during maintenance operations. Flexible exhaust hoses may be used to provide local ventilation to points at which maintenance is being performed. All non-essential workers should be evacuated from the area when equipment is opened for maintenance or cleaning.

When maintenance is conducted on equipment contaminated with acrylonitrile, all safety precautions applicable to flammable

substances must be followed. Make sure that all electrical equipment is shut off and locked during maintenance procedures.

A permit system that ensures close supervision during high risk procedures, such as opening process lines or vessel entry, can help to ensure safety.

Storage and Dispensing of Acrylonitrile

Pure acrylonitrile can spontaneously polymerize, resulting in a build-up of pressure and heat that can cause the container to explode. Suppliers therefore mix an inhibitor with acrylonitrile to prevent this reaction. However, this inhibitor can deteriorate with time, and it is important to avoid storing acrylonitrile for longer than four months. Samples of stored acrylonitril should be analysed weekly for inhibitor content and polymer formation.

Even when mixed with an inhibitor, acrylonitrile can polymerize in the presence of a number of substances and physical agents including the following:

- peroxides
- hydroperoxides
- strong bases such as sodium hydroxide or ammonia
- strong acids
- temperatures above 65.5°C (150°F)
- high energy radiation (e.g. ultraviolet light, X-rays and gamma rays).

Therefore, care must be taken to make sure that acrylonitrile is never added to a container that may be contaminated with substances such as those listed above and that it is never subjected to high heat or radiation. Outdoor storage tanks should be painted white to reflect radiation from the sun. Interiors of storage containers should never be coated with alkaline coatings.

Details regarding proper unloading procedures can be obtained from the supplier—make sure that all precautions are observed. Top unloading of tank cars can minimize worker exposure and reduce the likelihood of spills. Valves with a spring-loaded closure that self seals when the hose is disconnected can reduce spillage.

All areas where unloading or dispensing is conducted should have emergency protective equipment, showers, eyewash fountains, fire fighting equipment, first-aid kits and spill clean-up equipment readily available. Workers not involved in unloading or dispensing should be evacuated from the area during these operations.

Acrylonitrile containers must be electrically grounded during unloading. Use only non-sparking tools when opening drums containing acrylonitrile. All safety precautions applicable to the storage and dispensing of flammable liquids must be followed.

Acrylonitrile vapour can polymerize and clog vents in storage vessels. Therefore, vents should be checked regularly to make sure they are not plugged.

Clean-Up of Spills

A large spill of acrylonitrile presents a fire and explosion hazard. All spark- and flame-producing work in the area must be stopped immediately if such a spill occurs.

Where it is possible that a spill of acrylonitrile may occur, a written emergency procedure must be developed, outlining all steps to be taken in the event of a spill. One staff member on each shift should be designated as responsible for carrying out emergency procedures.

All workers not involved in the clean-up must be evacuated from the area of the spill. All workers cleaning up the acrylonitrile must

wear appropriate protective clothing and respirators. Moveable local exhaust ducts can be placed over the spill to collect vapours.

Acrylonitrile spills can be cleaned up by flushing with water or by absorbing the liquid onto an appropriate solid, such as activated carbon or vermiculite. There are also foams available that may be used to clean up the spill.

Disposal

Any waste contaminated with acrylonitrile must be treated as a hazardous industrial waste and disposed of in accordance with the requirements of the Ministry of the Environment. This includes any water, foam or solid used to clean up an acrylonitrile spill.

First Aid and Safety Precautions

Safety showers and eyewash fountains must be accessible wherever acrylonitrile is used. First aid procedures (summarized in Appendix 1 of this guide) and a phone number for medical aid should be posted in an accessible location.

An emergency first aid kit should be kept at each site where acrylonitrile is used. These kits should contain a supply of acrylonitrile antidote, such as amyl nitrite pearls, for use in cases of overexposure. At least one staff member on each shift should be trained in the proper use of this antidote and other first aid procedures for acrylonitrile poisoning. As amyl nitrite can be toxic itself, it must be administered by someone who is trained to do so.

Protective Clothing

It is essential that protective clothing impervious to acrylonitrile be used wherever contact with the liquid is possible. This clothing should include coveralls, gloves, head covering, boots and safety

goggles. If acrylonitrile is splashed onto this protective clothing, it should be washed off with water before the clothing is removed. If non-impervious clothing becomes contaminated with acrylonitrile, it must be removed immediately and not worn again until it is decontaminated. Otherwise, the acrylonitrile may be absorbed through the skin or cause skin injury. If leather shoes become contaminated with acrylonitrile, they must be removed immediately and discarded because of the capacity of leather to retain acrylonitrile.

The employer must take responsibility for cleaning all clothing that is contaminated with acrylonitrile and for ensuring that laundry workers are aware of the hazards of cleaning acrylonitrile-contaminated material.

Respiratory Protection

The type of respirator that should be worn to protect against exposure to acrylonitrile depends on the concentration of acrylonitrile in the air. The Code for Respiratory Equipment for Acrylonitrile, which is referenced by the regulation, specifies the type of respirator required for different conditions of exposure. A written respirator program must be established, and use of respirators should conform to the practices advised in Chapter 5 of **A General Guide to the Regulations.**

The Type of Respirator Required

The respiratory equipment provided by an employer and used by a worker must meet or exceed the following requirements:

Concentration of Airborne Acrylonitrile	Type of Respirator Required
Less than or equal to 20 ppm	Any chemical cartridge respirator with organic vapour cartridge and half or full facepiece.
Greater than 20 ppm	Positive pressure supplied air respirator with full facepiece (Type C).
Escape	Any chemical cartridge respirator with organic vapour cartridge and half or full facepiece, or self-contained breathing apparatus with full facepiece operated in pressure demand or other positive pressure mode.

Note: 1. Respirators need not be worn if the time-weighted average exposure is less than 2 ppm. However, if a worker wishes to use a respirator, the correct type of respirator must be worn.

2. Since the odour threshold is above 2 ppm, the organic vapour cartridge must be replaced at the beginning of each work shift or after eight hours' use.

Air Monitoring for Acrylonitrile

Chapter 6 of **A General Guide to the Regulations** describes the way to conduct air monitoring for exposure to designated substances. The Code for Measuring Airborne Acrylonitrile, referenced by the regulation, must be followed when conducting sampling and analysis to determine the personal exposure of workers to acrylonitrile and to ensure compliance with the exposure limits. This requirement is subject to section 17 of the regulation, which allows deviation from this Code as long as the employer can demonstrate that the alternative methods used are at least as accurate and precise as those set out in the Code. It is the responsibility of each employer to ensure that the alternative procedure is equivalent.

While an employer must meet these requirements, it may also be useful to use a monitoring method that does not require laboratory analysis for routine checks that controls are operating effectively or for obtaining an indication of acrylonitrile concentration in an emergency situation. Direct-reading instruments and colorimetric indicator tubes are available to provide an immediate indication of acrylonitrile levels. Where leaks of acrylonitrile from enclosed equipment may occur, such methods can be used in a routine program of leak detection. Direct-reading instruments can be coupled with an alarm system to warn of high air levels of acrylonitrile.

Training

The acrylonitrile regulation requires that the control program include provisions for a training program for all supervisors and workers affected by the acrylonitrile control program. Topics that should be covered in the training program include:

- health effects and symptoms of acrylonitrile exposure;
- how acrylonitrile is used in the specific workplace, and operations that may result in exposure;
- engineering controls in place to prevent acrylonitrile exposure, and ways of determining whether these controls are operating properly;
- work practices, housekeeping measures and hygiene practices that must be observed to control exposure to acrylonitrile;
- emergency procedures, including spill clean-up and first aid;
- proper use and maintenance of protective clothing and respirators; and
- details of the medical surveillance program and the purpose of clinical tests used by the examining physician.

4. Medical Surveillance for Exposure to Acrylonitrile

The acrylonitrile regulation requires that the control program provides for a medical surveillance program, which must include:

- pre-employment and pre-placement examinations;
- periodic medical examinations;
- clinical tests;
- health education; and
- record keeping.

The medical surveillance program is outlined in detail in the Code for Medical Surveillance of Acrylonitrile Exposed Workers and is designed to protect the health of workers through the education of all staff to the health hazards associated with acrylonitrile exposure.

The objectives of the medical surveillance program are both preventive and remedial. The pre-placement medical examinations and clinical tests should identify workers with conditions that may be aggravated by exposure to acrylonitrile and should establish a baseline measure for determining changes in health.

Health education for workers on the health effects from exposure to acrylonitrile and the manner in which exposure can be limited are also preventive functions of the program.

Section 3 of the Code explains what the physician should look for at the pre-placement and periodic medical examinations. Medical records kept by the physician should include the information listed in section 6 of the Code. The frequency of the periodic medical

examination is determined by the examining physician, but must be at least once every three years unless clinical test results indicate that it should be performed more often.

Clinical Tests

Section 4 of the Code lists a number of clinical tests that may aid in the assessment of a worker's fitness for exposure to acrylonitrile. Whether any of these tests are used and how frequently they are performed shall be decided by the examining physician.

The following tests have been suggested as being of use depending on the exposure and the physician's judgement.

1) Liver function tests: These are blood tests that measure the amount of several different liver enzymes in the blood. They may help to indicate whether there has been any change in liver function that may be related to acrylonitrile exposure.

2) Fecal occult blood test: This test for blood in the stool may be useful in the detection of abnormalities of the gastro-intestinal tract.

3) X-rays.

4) Acrylonitrile absorption tests: These are tests that measure the concentration of acrylonitrile or its metabolites in the blood or urine.

Action Levels

No specific action levels are set for any of the clinical tests that may be used in medical surveillance for acrylonitrile. The examining physician is to assess the worker's fitness for exposure to acrylonitrile on the basis of the medical examination and the results of any clinical tests that are used. If symptoms or signs resulting

from exposure to acrylonitrile are present, the worker must be removed from acrylonitrile exposure. The examining physician decides when the worker may return to work.

The Examining Physician

The acrylonitrile regulation does not stipulate who shall be the examining physician, thus allowing the worker to select the doctor of his or her choice. As a result, the examining doctor may be the company doctor, a private consultant with whom the employer contracts services, a physician on the staff of a clinic or the personal physician of the worker. Every examining physician must know the Code for Medical Surveillance and his or her responsibilities.

Where there is more than one examining physician, a physician should be appointed in a co-ordinating role. The role of the co-ordinating physician, who should be selected jointly by the employer and the joint health and safety committee, should be to standardize examination and test procedures, maintain medical records and identify any trends in examinations and test results.

Physician Reporting Protocol

The regulation requires the examining physician to advise the employer and the worker whether the worker is fit, fit with limitations or unfit for exposure to acrylonitrile. This determination is a professional judgement based on the results of medical examinations and clinical tests. **The physician must give this opinion without disclosing to the employer the results of the examinations or tests.**

If a physician determines that a worker is unfit or fit with limitations for exposure to acrylonitrile as a result of exposure to acrylonitrile in the workplace, he or she must also communicate this advice in writing to the joint committee. In doing so, the physician

must give his or her opinion on how the committee should interpret this advice. The committee must receive this advice on a confidential basis. If the physician has advised the employer that a worker is fit with limitations or unfit, he or she must also report this information to the Chief Physician of the Occupational Health Medical Service of the Ministry of Labour. These requirements are specified in subsections 16(1), 16(3) and 16(5) of the regulation.

5. Appendices

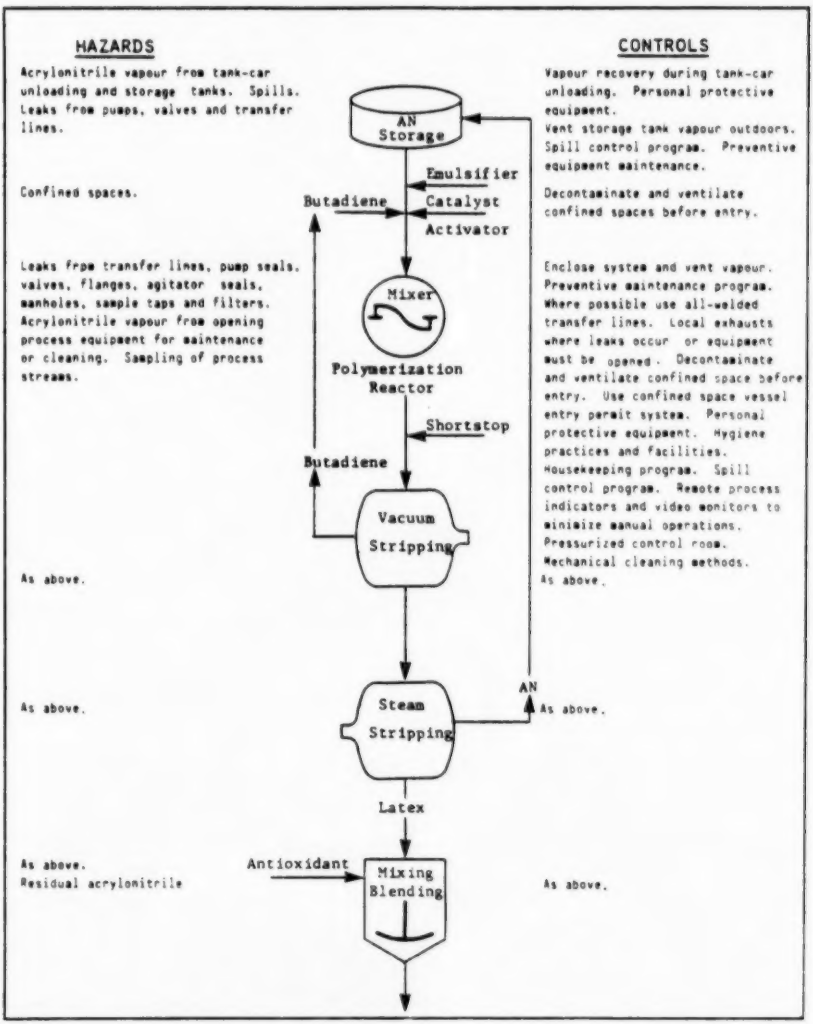
Appendix 1 — First Aid for Over-Exposure to Acrylonitrile

Exposure	First Aid
Eyes	If liquid acrylonitrile is splashed in the eyes, immediately flush the eyes with water for at least 15 minutes. Contact physician.
Skin	Remove contaminated clothing and shoes. Wash skin thoroughly with soap and water for 15 minutes. If systemic poisoning has occurred (i.e. as a result of absorption), follow instructions under "Inhalation".
Inhalation	Remove to fresh air. If not breathing, give artificial respiration. Administer amyl nitrite.* Contact physician. Keep under medical care for 24 to 48 hours.
Ingestion	If not breathing, give artificial respiration. Administer amyl nitrite.* If conscious, give two glasses of water and induce vomiting. Contact physician. Keep under medical care for 24 to 48 hours.

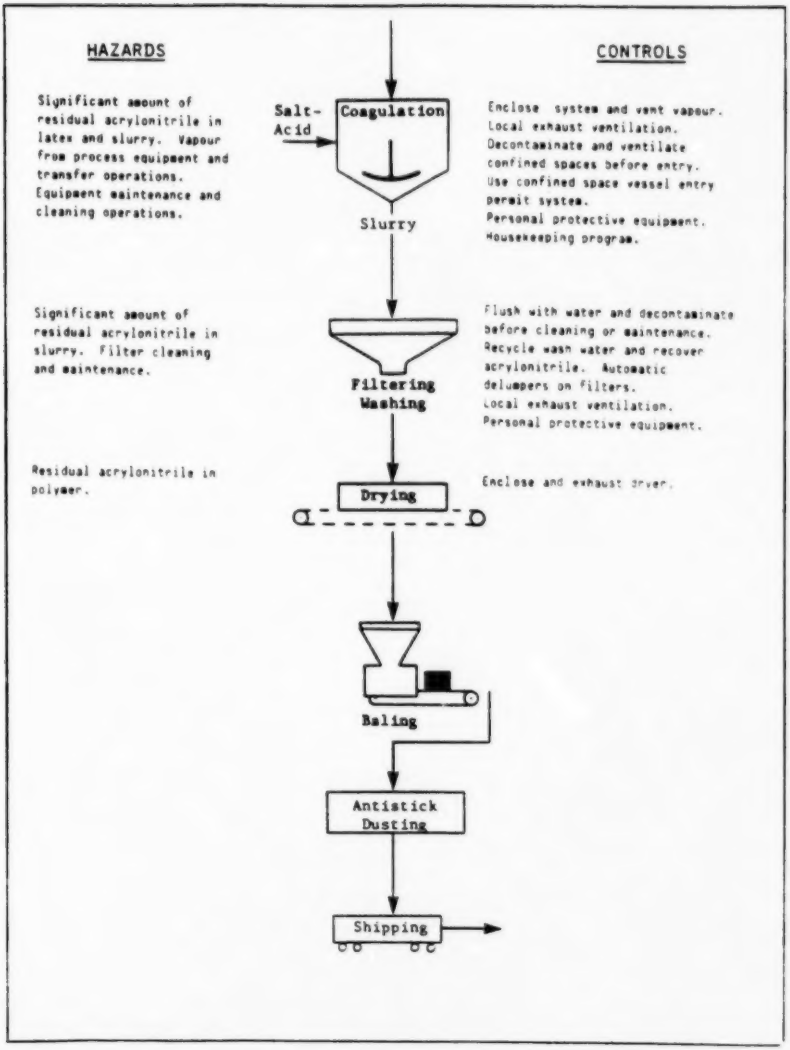
* Amyl nitrite must be administered by someone who is trained to do so.

Appendix 2 — Process Flow Sheets for Inspectors

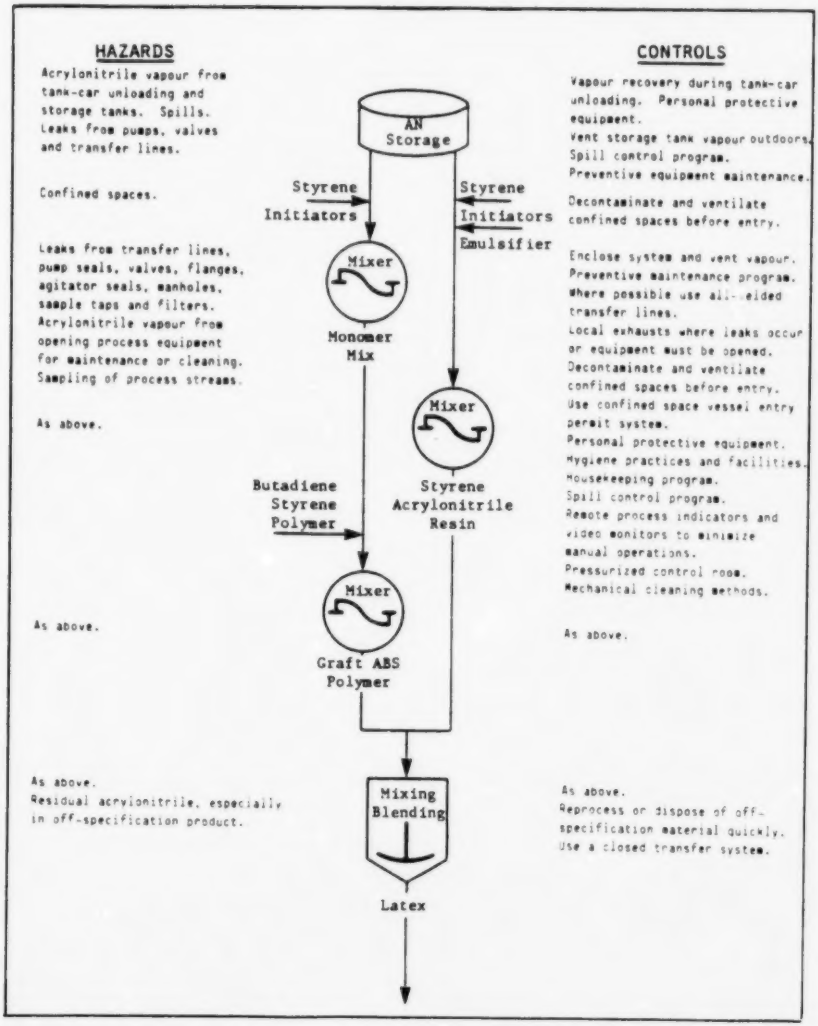
FLOW SHEET FOR NITRILE RUBBER MANUFACTURE ACRYLONITRILE


HAZARDS
CONTROLS
Acrylonitrile vapour from tank-car unloading and storage tanks. Spills. Leaks from pumps, valves and transfer lines.
Vapour recovery during tank-car unloading. Personal protective equipment. Vent storage tank vapour outdoors. Spill control program. Preventive equipment maintenance.
AN Storage
Emulsifier
Butadiene
Catalyst
Activator
Confined spaces.
Decontaminate and ventilate confined spaces before entry.
Leaks from transfer lines, pump seals, valves, flanges, agitator seals, manholes, sample taps and filters. Acrylonitrile vapour from opening process equipment for maintenance or cleaning. Sampling of process streams.
Mixer
Polymerization Reactor
Enclose system and vent vapour. Preventive maintenance program. Where possible use all-welded transfer lines. Local exhausts where leaks occur or equipment must be opened. Decontaminate and ventilate confined space before entry. Use confined space vessel entry permit system. Personal protective equipment. Hygiene practices and facilities. Housekeeping program. Spill control program. Remote process indicators and video monitors to minimize manual operations. Pressurized control room. Mechanical cleaning methods.
Shortstop
Butadiene
Vacuum Stripping
As above.
As above.
AN
As above.
Steam Stripping
As above.
Latex
As above.
Residual acrylonitrile
Antioxidant
Mixing Blending
As above.

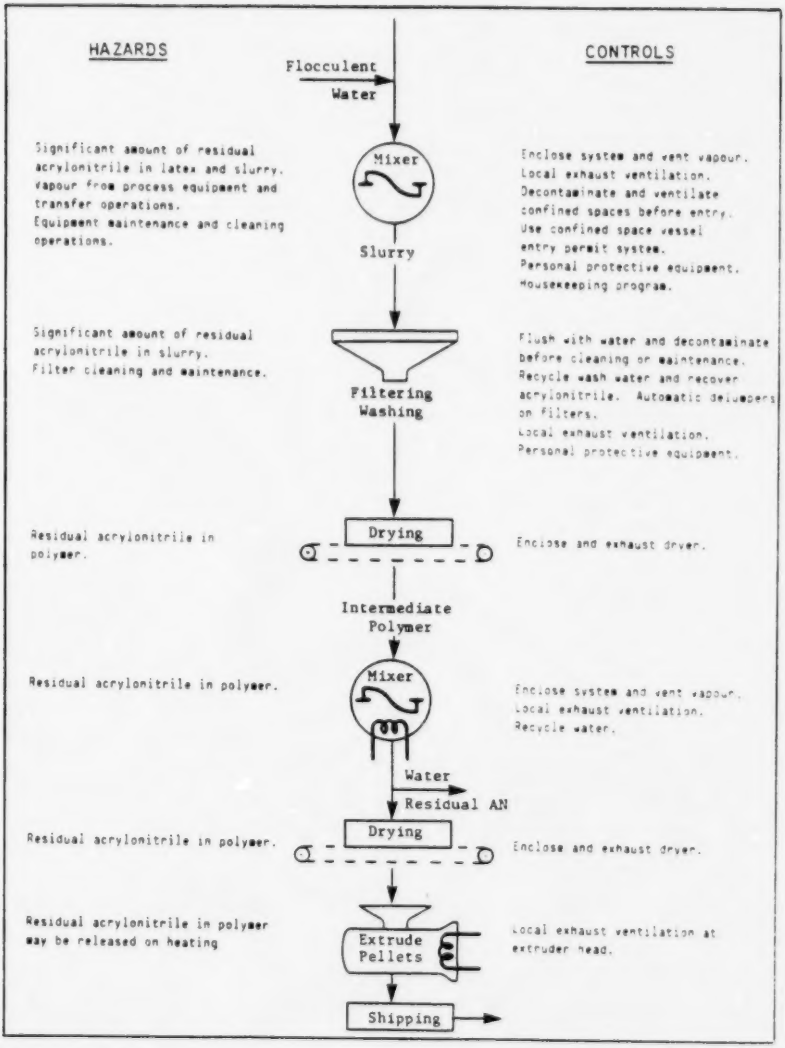
NITRILE RUBBER MANUFACTURE
ACRYLONITRILE
(cont'd.)


HAZARDS
CONTROLS
Significant amount of residual acrylonitrile in latex and slurry. Vapour from process equipment and transfer operations. Equipment maintenance and cleaning operations.
Salt-Acid
Coagulation
Slurry
Enclose system and vent vapour. Local exhaust ventilation. Decontaminate and ventilate confined spaces before entry. Use confined space vessel entry permit system. Personal protective equipment. Housekeeping program.
Significant amount of residual acrylonitrile in slurry. Filter cleaning and maintenance.
Filtering
Washing
Flush with water and decontaminate before cleaning or maintenance. Recycle wash water and recover acrylonitrile. Automatic delumpers on filters. Local exhaust ventilation. Personal protective equipment.
Residual acrylonitrile in polymer.
Drying
Enclose and exhaust dryer.
Baling
Antistick Dusting
Shipping

FLOW SHEET FOR ABS RESIN MANUFACTURE
ACRYLONITRILE


HAZARDS
CONTROLS
Acrylonitrile vapour from tank-car unloading and storage tanks. Spills. Leaks from pumps, valves and transfer lines.
Vapour recovery during tank-car unloading. Personal protective equipment.
Vent storage tank vapour outdoors.
Spill control program.
Preventive equipment maintenance.
AN Storage
Confined spaces.
Decontaminate and ventilate confined spaces before entry.
Styrene
Initiators
Styrene
Initiators
Emulsifier
Leaks from transfer lines, pump seals, valves, flanges, agitator seals, manholes, sample taps and filters. Acrylonitrile vapour from opening process equipment for maintenance or cleaning. Sampling of process streams.
Enclose system and vent vapour.
Preventive maintenance program.
Where possible use all-welded transfer lines.
Local exhausts where leaks occur or equipment must be opened.
Decontaminate and ventilate confined spaces before entry.
Use confined space vessel entry permit system.
Personal protective equipment.
Hygiene practices and facilities.
Housekeeping program.
Spill control program.
Remote process indicators and video monitors to minimize manual operations.
Pressurized control room.
Mechanical cleaning methods.
Mixer
Monomer Mix
Mixer
As above.
Butadiene Styrene Polymer
Styrene Acrylonitrile Resin
Mixer
Graft ABS Polymer
As above.
As above.
As above.
Residual acrylonitrile, especially in off-specification product.
Mixing Blending
Latex
As above.
Reprocess or dispose of off-specification material quickly.
Use a closed transfer system.

ABS RESIN MANUFACTURE
ACRYLONITRILE
(cont'd.)


HAZARDS
CONTROLS
Flocculent
Water
Mixer
Slurry
Significant amount of residual acrylonitrile in latex and slurry. Vapour from process equipment and transfer operations. Equipment maintenance and cleaning operations.
Enclose system and vent vapour. Local exhaust ventilation. Decontaminate and ventilate confined spaces before entry. Use confined space vessel entry permit system. Personal protective equipment. Housekeeping program.
Significant amount of residual acrylonitrile in slurry. Filter cleaning and maintenance.
Filtering
Washing
Flush with water and decontaminate before cleaning or maintenance. Recycle wash water and recover acrylonitrile. Automatic deluggers on filters. Local exhaust ventilation. Personal protective equipment.
Residual acrylonitrile in polymer.
Drying
Enclose and exhaust dryer.
Intermediate
Polymer
Residual acrylonitrile in polymer.
Mixer
Enclose system and vent vapour. Local exhaust ventilation. Recycle water.
Water
Residual AN
Residual acrylonitrile in polymer.
Drying
Enclose and exhaust dryer.
Residual acrylonitrile in polymer may be released on heating.
Extrude
Pellets
Local exhaust ventilation at extruder head.
Shipping

Appendix 3 — Data Sheet for Inspectors

DATA SHEET FOR INSPECTORS

ACRYLONITRILE*

CAS. REG. NO. 107-13-1

OTHER NAMES

AN
Cyanoethylene
Propenenitrile
VCN
Vinyl cyanide

TRADE NAMES

Acrylon
Carbacryl
Fumigrain
Ventox

POTENTIAL EXPOSURE

USES: Synthetic fibres, acrylonitrile-butadiene-styrene (ABS) and styrene-acrylonitrile (SAN) resins and plastics, nitrile rubbers, coatings, and adhesives are made from acrylonitrile. It is also a chemical intermediate in the synthesis of anti-oxidants. Acrylonitrile may be used as a pesticide.

OCCUPATION(S):

Acrylic ABS and SAN resin makers and processors
Adhesive makers
Coatings makers
Nitrile rubber workers
Paint makers
Synthetic fibre makers
Textile finish makers

STORAGE

Protect against physical damage.

Store in tightly closed containers in a cool, dark location away from sources of ignition, oxidants (especially bromine) and alkalies.

Do not store acrylonitrile that does not contain an inhibitor.

Check inhibitor content weekly.

INCOMPATIBLE WITH: Aluminum, copper, alkalies, ammonia, amines and strong oxidants. Pure acrylonitrile may polymerize, with consequent pressure build-up and possible rupture of the container. It should therefore be stored with an inhibitor.

LABELLING MUST BE ADEQUATE

EXPOSURE LIMITS

Worker exposure shall be reduced to the lowest practical level and in any case shall not exceed 2 parts acrylonitrile per million parts of air by volume or 4.3 mg acrylonitrile per m^3 of air.

MAXIMUM EXPOSURE CONCENTRATION: 10 ppm, 21.7 mg/m^3

IMMEDIATE DANGER LEVEL: 4000 ppm, 8600 mg/m^3

PROPERTIES

FORMULA: CH_2CHCN

DESCRIPTION: Clear, colourless to pale yellow liquid

ODOUR: Onion, garlic pungency

Odour Threshold: 21 ppm (greater than TWAEL)

SPECIFIC GRAVITY (20°C): 0.806

VAPOUR DENSITY (Air = 1): 1.83

VAPOUR PRESSURE (20°C): 11.1 kPa (83 mmHg)

BOILING POINT: 77.3°C

FIRE AND EXPLOSION

Highly flammable liquid. Forms explosive mixtures with air.

EXTINGUISHING MEDIA: Use carbon dioxide, "alcohol" foams, or dry chemical. Use water spray to keep fire-exposed containers cool.

FLASH POINT (closed cup): -1°C

AUTO-IGNITION TEMPERATURE: 481°C

EXPLOSIVE LIMITS (By volume in air):

Lower 3% Upper 17%

HAZARDOUS DECOMPOSITION PRODUCTS: When heated or burned, acrylonitrile may decompose to hydrogen cyanide gas and oxides of nitrogen.

LEAKS, SPILLS AND DISPOSAL

Prepare written plan in advance for handling emergencies.

For major leaks or spills, evacuate area, eliminate all sources of ignition and adequately ventilate.

Wear suitable protective clothing and respirators (see safety equipment section). Self-contained breathing apparatus recommended.

Clean up all spills with inert absorbents such as sand, paper or vermiculite. Neutralize remainder with chlorine bleach (hypochlorite solution). Do not use dry brooms or compressed air to clean acrylonitrile-contaminated floors or surfaces.

Acrylonitrile may be disposed of by incineration.

NEUTRALIZING CHEMICALS: Calcium hypochlorite or other chlorine bleaching solutions.

* ACRYLONITRILE IS A DESIGNATED SUBSTANCE
(Ont. Reg. 733/80)

Data Sheet (Cont'd.)

ACRYLONITRILE

CAS. REG. NO. 107-13-1

SAFETY PRACTICES

PRECAUTIONS:

Do not smoke or eat in areas of use.

Reduce exposure to the lowest level feasible.

Eliminate all sparks, flames, and ignition sources from the work area.

Inform workers of fire, explosion and health hazards of acrylonitrile use.

Instruct workers in correct use of cyanide antidote kits (see safety equipment section).

Change acrylonitrile-contaminated clothing immediately.

VENTILATION:

Enclose operations wherever possible to control workplace exposure.

Moving parts of the ventilation system (fans, motors) should be non-sparking and explosion proof.

SAFETY EQUIPMENT

Coveralls, gloves and shoe coverings impervious to acrylonitrile should be available where physical contact is possible. Rubber equipment will soften and swell and should be frequently inspected. (Polyethylene gloves offer better protection). A cyanide antidote kit that contains amyl nitrite ampoules or pearls, sterile sodium thiosulphate and sodium nitrite solutions, and suitable syringes and needles for injections should be available for emergencies. Appropriate personnel should be trained in the proper use of these kits.

RESPIRATORS:

CONC. (ppm)	TYPE
Less than or equal to 20	Chemical cartridge respirator with organic vapour cartridge and half or full facepiece.
Greater than 20	Positive pressure supplied-air respirator with full facepiece (Type C).
Escape	Self-contained breathing apparatus with full facepiece operated in pressure demand or chemical cartridge respirator with organic vapour cartridge and half or full facepiece.

Note: Respirators must not be a substitute for engineering controls (e.g. adequate ventilation).

HEALTH EFFECTS - PROTECTION - FIRST AID

EXPOSURE	SYMPTOMS	PROTECTION	FIRST AID
EYES:	Irritation, corneal damage	Goggles and full facepiece respirator. Eyewash facilities available.	Immediately flush with water for at least 15 minutes. Contact physician.
SKIN:	Irritation, itching, blisters Notes: absorption through skin may cause systemic symptoms (see inhalation)	Gloves, protective clothing (see safety equipment section)	Wash thoroughly with soap and water.
INHALATION:	Headache, sneezing, nausea, weakness, light-headedness, vomiting, asphyxia, death	Use proper respirator (see safety equipment section).	Remove to fresh air. Contact physician. Administer artificial respiration if required; use 100% oxygen to maintain high blood oxygen tension. Administer amyl nitrite. Keep under medical care for 24 to 48 hours.
INGESTION:	Nausea, vomiting, diarrhea	No food, drink or smoking in areas of use. Good hygiene practices.	Induce vomiting. Contact physician.

LONG TERM: Recent epidemiological evidence suggests that prolonged exposure to acrylonitrile may be associated with an excess of lung and other types of cancer. Repeated skin contact may result in dermatitis.

ADDITIONAL INFORMATION

This data sheet is intended to impart basic information only. If additional information or specific references concerning acrylonitrile are required contact your local field office of the Occupational Health Branch.

07/87

Appendix 4 — Regulations made under the Occupational Health and Safety Act Revised Statutes of Ontario, 1980, Chapter 321 as at August 31, 1987

Acrylonitrile:	O. Reg. 733/84 as amended by O. Reg. 23/87.
Arsenic:	O. Reg. 176/86 as amended by O. Reg. 23/87.
Asbestos:	O. Reg. 570/82 as amended by O. Reg. 655/85, O. Reg. 23/87.
Asbestos on Construction Projects and in Building and Repair Operations:	O. Reg. 654/85.
Benzene:	O. Reg. 732/84 as amended by O. Reg. 23/87.
Biological or Chemical Agents, Control of Exposure to:	O. Reg. 654/86 as amended by O. Reg. 707/86, O. Reg. 339/87.
Coke Oven Emissions:	O. Reg. 517/82 as amended by O. Reg. 23/87.
Construction Projects:	R.R.O. 1980, Reg. 691 as amended by O. Reg. 635/86.
Critical Injury Defined:	O. Reg. 714/82.
Diving Operations:	O. Reg. 634/86.
Elevated or Suspended Work Places on Building Facades:	O. Reg. 156/84.
Ethylene Oxide:	O. Reg. 146/87.
Fire Fighters Protective Equipment:	O. Reg. 125/83.
Industrial Establishments:	R.R.O. 1980, Reg. 692.
Isocyanates:	O. Reg. 455/83 as amended by O. Reg. 23/87.
Lead:	O. Reg. 536/81 as amended by O. Reg. 23/87.
Mercury:	O. Reg. 141/82 as amended by O. Reg. 23/87.

Appendix 4 — (cont'd)

Mines and Mining Plants:	R.R.O. 1980, Reg. 694 as amended by O. Reg. 226/83, O. Reg. 569/83, O. Reg. 365/86, O. Reg. 450/86, O. Reg. 569/86, O. Reg. 654/86, O. Reg. 258/87.
Oil and Gas-Offshore:	O. Reg. 633/86.
Silica:	O. Reg. 769/83 as amended by O. Reg. 23/87.
Teachers:	O. Reg. 191/84.
University Academics and Teaching Assistants:	O. Reg. 307/84.
Vinyl Chloride:	O. Reg. 516/82 as amended by O. Reg. 23/87.
X-Ray Safety:	O. Reg. 632/86.
Inventory of Agents or Combinations of Agents for the Purpose of Section 21 of the Act:	R.R.O. 1980, Reg. 693.

For a complete reference to the Regulations made under the Occupational Health and Safety Act, recourse should be made to the Annual Consolidated Index to the Regulations of Ontario.

Appendix 5 — Ministry of Labour District Offices

Barrie
Industrial Health and Safety
114 Worsley Street
L4M 1M1
(705) 722-6642
1-800-461-4383*

Elliot Lake
Mining Health and Safety
Algo Centre
151 Ontario Avenue
P5A 2T2
(705) 848-2885

Hamilton
119 King Street West
L8N 3Z9
Construction Health and Safety
Industrial Health and Safety
(416) 521-7736
1-800-263-6906(8)*

Kingston
1055 Princess Street, Suite 105
K7L 1H3
Construction Health and Safety
Industrial Health and Safety
(613) 545-4340
1-800-267-0915*
Mining Health and Safety
(Suite 301)
(613) 545-4335
1-800-267-0915*

Kirkland Lake
Mining Health and Safety
38 Second Street
P2N 1R1
(705) 567-5241

Kitchener
824 King Street West
N2G 1G1
Construction Health and Safety
Industrial Health and Safety
(519) 744-8101
1-800-265-2373*

London
205 Oxford Street East
N6 6
Construction Health and Safety
Industrial Health and Safety
Mining Health and Safety
(519) 439-3231
1-800-265-4707*

North Bay
Industrial Health and Safety
1500 Fisher Street
Northgate Square
P1B 2H3
(705) 476-2711
1-800-461-1654*

Ottawa
2197 Riverside Drive
K1H 7X3
Construction Health and Safety
Industrial Health and Safety
(613) 523-7530
1-800-267-1916*

Peterborough
139 George Street North
K9J 3G6
Construction Health and Safety
(705) 742-3436
1-800-461-1425*
Industrial Health and Safety
(705) 876-1800
1-800-461-1425*

Richmond Hill
Mining Health and Safety
10720 Yonge Street
L4C 3C9
(416) 884-6551
1-800-268-3829*

St. Catharines
205 King Street
L2R 3J5
Construction Health and Safety
Industrial Health and Safety
(416) 682-7261
1-800-263-7260*

Sarnia
Industrial Health and Safety
700 Christina Street North
N7V 3C2
(519) 336-1200
1-800-265-1416*

Sault Ste. Marie
390 Bay Street
P6A 1X2
Construction Health and Safety
Industrial Health and Safety
(705) 949-3331
1-800-461-7268*

Sudbury
199 Larch Street
P3E 5P9
Construction Health and Safety
Industrial Health and Safety
(705) 675-4455
1-800-461-4000*
Mining Health and Safety
(705) 675-4464
1-800-461-4000*

Sudbury
260 Cedar Street
P3B 3X2
Mining Health and Safety
(Chief Engineers)
(705) 675-4468
1-800-461-4000*

Thunder Bay
435 James Street South
P7E 6E3
Construction Health and Safety
Industrial Health and Safety
(807) 475-1691
1-800-465-5016(7)*
Mining Health and Safety
(807) 475-1675
1-800-465-5016(7)*

Timmins
273 Third Avenue
P4N 1E2
Construction Health and Safety
Industrial Health and Safety
Mining Health and Safety
(705) 267-6231
Zenith 57740* (Mining)

Toronto East
2500 Lawrence Avenue East
Scarborough
M1P 2R7
Construction Health and Safety
Industrial Health and Safety
(416) 750-3557

Toronto West
2 Robert Speck Parkway
Mississauga
L4Z 1H8
Construction Health and Safety
Industrial Health and Safety
(416) 273-7800
1-800-268-2966(7)*

Windsor
500 Ouellette Avenue
Suite 305
N9A 1B3
Construction Health and Safety
Industrial Health and Safety
(519) 256-8278
1-800-265-5140(4)*

Occupational Health Branch Laboratory
101 Resources Road
Weston, Ontario
M9P 3T1
(416) 248-7261

Head Office
400 University Avenue
Toronto, Ontario
M7A 1T7

Construction Health and Safety
(416) 965-7161
1-800-268-8013*
Industrial Health and Safety
(416) 965-4125
1-800-268-8013*

Mining Health and Safety
(416) 965-1328
1-800-268-8013*
Occupational Health
(416) 965-3211
1-800-268-8013*
Special Studies and Services
(416) 965-2493
1-800-268-8013*
Standards and Programs
(416) 965-8710
1-800-268-8013*

*Toll free line. For callers located within the area code but outside the local calling area of this city. Consult the blue pages in your local telephone directory for additional information. The Ministry may also be reached 24 hours a day through the emergency telephone number in Toronto (416) 965-1211.